THE UPPER CAMBRIAN TRILOBITE IRVINGELLA **NUNEATONENSIS** (SHARMAN)

by A. W. A. RUSHTON

ABSTRACT. Irvingella nuneatonensis (Sharman 1886), of which the complete dorsal exoskeleton is known, is redescribed, illustrated for the first time, and distinguished from other species. The ventral cephalic sutures and rostrum are like those of *Dunderbergia* (family Elviniidae). Three abnormally developed individuals are described. I, nuneatonensis comes from the upper part of the Zone of Olenus (above the base of the Subzone of Olenus dentatus) and its horizon is not below the upper part of the Elvinia Zone of the Upper Cambrian sequence in the U.S.A.

In the course of the Geological Survey's investigation of the pre-Carboniferous rocks in the neighbourhood of the Warwickshire coalfield in the English Midlands (Strahan 1886), several specimens of a trilobite were collected from the Upper Cambrian shales ('Lower Silurian' in the original account) exposed in the Midland Railway Cutting between Nuneaton and Stockingford; they were described by Sharman (1886, p. 565) as a new species, Olenus nuneatonensis. Lapworth (1898, p. 347), apparently recognizing that the species was not a true olenid, referred to it as 'an Olenoid form, Olenus (?) nuneatonensis', but its affinities were not made known until Stubblefield (1932, p. 65) assigned it to the genus *Irvingella* Ulrich and Resser (*in* Walcott 1924). Palmer (1965, pp. 20-21, 45-46) showed that Irvingella is a widely distributed genus, and is a useful index for inter-continental correlation since it has a short stratigraphical range; I. nuneatonensis is of particular importance in this connexion because it provides the clearest evidence so far found for the stratigraphical position of *Irvingella* in the Upper Cambrian succession of Europe, correlation of which with the coeval succession in the United States of America is notoriously difficult. I. nuneatonensis is also of interest in being the only described species of the genus in which the rostrum and entire thorax are known.

The techniques and terminology employed in this study are the same as those given by the writer in an earlier work (Rushton 1966); in particular it should be noticed that the occipital and glabellar furrows are referred to respectively as S0, S1, S2, etc. (counting from the back forwards), and the occipital ring is excluded from the glabella.

Genus IRVINGELLA Ulrich and Resser in Walcott 1924

Type species, by original designation. Irvingella major Ulrich and Resser in Walcott 1924.

The genus Irvingella has been discussed by Palmer (1960) and Öpik (1963), and the species of the genus were reviewed by Palmer (1965), who considered the following valid: I, major Ulrich and Resser, I. angustilimbatus Kobayashi, I. flohri Resser, I. suecica Westergård, and I. transversa Palmer, and, with some doubt, I. nuneatonensis (Sharman), I. platycephala Rusconi, and I. tropica Öpik; he reserved comment on I. taitzehuensis Lu, Komaspis (Parairvingella) convexa Kobayashi, and K. (P.) megalops Kobayashi,

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According to Kobayashi (1954 and elsewhere) *Irvingella* is a genus of the Komaspididae, which family he regarded as descended from a relative of the genus *Bathynotus* Hall. However, as discussed by Öpik (1963, pp. 94, 95) and Palmer (1960, p. 73), the concept of the Komaspididae, based upon the inadequately known *Komaspis* Kobayashi (type species *K. typa* Kobayashi), is of doubtful value, and Palmer has advocated the grouping of *Irvingella* with the ptychopariacean family Elviniidae, suggesting that *Elviniella laevis* Palmer is the direct ancestor of the *Irvingella* species in the Great Basin region of the U.S.A. (Palmer 1965, p. 20). This idea receives some further support from the discovery that the rostrum and ventral sutures in a species of *Irvingella* (text-fig. 1b) are exactly like those of *Dunderbergia* (Palmer 1960, p. 64, fig. 8c), the latter being a genus of the Elviniidae and possibly directly related to *Elvinia* itself (Palmer 1965, p. 17); the ventral cephalic sutures of *Bathynotus* have a different ('Bathynotid') pattern (Harrington *et al.* 1959, p. 065, fig. 48 *I* and p. 067), and according to Lochman (1953, p. 890), the Bathynotidae are not related to *Irvingella*.

Irvingella nuneatonensis (Sharman 1886)

Plate 52, figs. 1-12; text-figs. 1, 2

- 1886 Olenus Nuueatonensis Sharman; Strahan, p. 548. (Nom. nud. in list).
- 1886 Olenus Nuneatonensis; Sharman, p. 565 (described, no figure).
- 1898 Oleuus (?) unneatonensis Sharman; Lapworth, pp. 347, 348 (mentioned and listed).
- 1932 Irvingella nuneatonensis (Sharman); Stubblefield, p. 65 (species transferred to Irvingella).
- 1954 Irvingella numeatoneusis (Sharman 1866 [sic]), [also attributed to 'Shorma (1731)']; Kobayashi, pp. 25, 27, 35, 41 (remarks, listed).
- 1965 Irvingella nuneatonensis (Sharman); Palmer, p. 46 (mentioned as possibly distinct from Irvingella major).

Material. Sharman's original material was all collected from one locality and is in the collection of the Institute of Geological Sciences (formerly Geological Survey and Museum), nos. GSM 50280-6,

EXPLANATION OF PLATE 52

Irvingella nuneatonensis (Sharman 1886).

- Fig. 1*a*-*d*. Cranidium, GSM 50285-6. *a*, dorsal view (latex cast); *b*-*d*, dorsal, lateral, and anterior views. × 2.5.
- Fig. 2. Cranidium showing palpebral lobe, GSM JR3134. $\times 2.5$.
- Fig. 3a-d. Cranidium, GSM JR3137. *a*, dorsal view with S3 distinct; *b*, left side viewed obliquely from above; *c*, anterior view showing supposed S4; *d*, right lateral view. $\times 2.5$.
- Figs. 4, 5. Immature cranidia showing anterior border, GSM JR3143, GSM 50282.×5.
- Fig. 6. Small axial shield, GSM 50283×5 .
- Fig. 7. Thorax of small individual with two free cheeks (slightly retouched), GSM $50284. \times 5$.
- Fig. 8. Lectotype, small dorsal shield with free cheeks displaced (slightly retouched), GSM $50280. \times 5$.

Fig. 9a, b. a, Pygidium, posterior part of thorax and ventral aspect of a free cheek (latex cast), GSM JR3126; b, the same free cheek, lateral (abaxial) view of interior surface. $\times 2.5$.

Fig. 10*a*-*c*. Part of thorax and pygidium, GSM JR 3125 (counterpart of JR3126, fig. 9). *a*-*c*, dorsal, lateral, and posterior views. × 2·5.

Fig. 11. Complete thorax with deformed pygidium, GSM JR3127 (latex cast). $\times 2.5$.

Fig. 12*a*, *b*. Fragment of thorax and pygidium, GSM JR3149. *a*, *b*, dorsal and posterior views. $\times 2.5$. All the specimens are in the collection of the Institute of Geological Sciences (formerly Geological Survey and Museum) and are internal moulds unless otherwise stated; for locality see text. All photographs by the writer; specimens whitened before photography except that in fig. 7, which was taken under alcohol.

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PLATE 52



RUSHTON, Upper Cambrian trilobite Irvingella nuneatonensis



JR3120–44, and JR3147–9. It consists of fragments of twenty-eight specimens including one dorsal shield (the lectotype), one axial shield, a cephalon, about six useful cranidia, and three or four fairly complete examples of the thorax, mostly with the pygidium attached. At a different locality the writer collected a small axial shield associated with part of a very large thorax, part of another thorax and a small pygidium with three thoracic segments attached; these specimens, thought to be of this species, are in the collection of the Sedgwick Museum, Cambridge, Nos. SM A57283–6.

All the specimens are preserved as internal and external moulds in grey or greenish silty and slightly micaceous shale. Much of their original convexity is preserved, the exoskeleton being thick and strong, but there are cracks in some of the specimens (e.g. Pl. 52, fig. 1*b*, in the occipital ring; fig. 3*a*, in the left cheek) which are probably due to the compression of compacting sediment. Morphologically, their effect is to increase the width and reduce the convexity of the affected part in relation to other parts. The lectotype has suffered adventitious frontal pressure which has fractured and foreshortened the cranidium, as stated by Palmer (1965, p. 46).

Lectotype. The lectotype is the small dorsal shield described by Sharman, GSM 50280 (Pl. 52, fig. 8).

Diagnosis. A species of *Irvingella* with a tapered glabella, the second and third pairs of lateral glabellar furrows (S2 and S3) distinct, the frontal area undivided in holaspid cranidia more than about 2–3 mm. long, the anterior ends of the eyes further apart than the width of the occipital ring, and interocular cheeks about half as wide as the glabella across a line through the anterior ends of S1.

Description. Cranidium approximately semicircular, convex in mature individuals. Cephalic axis long, tapering forwards, roughly parabolic in outline, slightly truncate in front but with the anterolateral corners rounded, strongly convex longitudinally and moderately convex transversely; the width is about five-sixths of the length. S1 deep, wide, lateral parts oblique backwards and slightly convex forwards, joined across the glabella by a transverse median portion; S2 distinct, less oblique, convex forwards, short; S3 nearly transverse, convex forwards, weak on external moulds but distinct on internal moulds, short; one specimen, GSM JR3137 (Pl. 52, fig. 3c), has a pair of pits which may represent S4. Occipital ring about one-sixth of the cephalic axial length. S0 deep, simple, concave forwards. In smaller specimens the glabella is relatively narrow and less convex.

Frontal area short, one-tenth or less of the cephalic axial length, bending down vertically in front. Two small cranidia (Pl. 52, figs. 4, 5, about 2.5 and 2.0 mm. long respectively) have a relatively longer frontal area divided into a preglabellar field and anterior border—a feature of immaturity, as in some other species of *Irvingella* (Palmer 1965). Preocular cheeks narrow. Interocular cheeks fairly flat, widening backwards, the width from the axial to the palpebral furrow at the level of the anterior ends of S1 just over half the glabellar width at the same level. Postocular cheeks short, bent down abaxially, mostly occupied by the posterior border and furrow. Smaller specimens have relatively wider cheeks. Palpebral furrow shallow. Palpebral lobe long, its chord twothirds or less of the length of the cephalic axis; depressed below the level of the interocular cheeks, curved (most sharply near the mid-length), and horizontal except at the ends which are bent abruptly down through a right angle; anterior ends opposite S3 and situated slightly further apart than the greatest width of the cephalic axis. Preocular facial sutures very short, converging forwards, just submarginal in front of the glabella. Postocular sutures divergent with a downward course behind the eye, curving inwards and upwards again across the posterior border, continuing adaxially for a short distance before curving forward to cut the doublure (text-fig. 1b, c).

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Free cheeks narrow anteriorly, wider behind, with straight spine which is almost round in cross-section; ocular surface steep; border-furrow weak or absent. Doublure curled under, tube-like (a feature of the Elviniidae; cf. Palmer 1960, p. 64), extended adaxially beyond the dorsal surface at both ends (Pl. 52, figs. 9a, b; text-fig. 1b). One cephalon (GSM JR3121) shows that the rostrum is about as wide as the anterior part



TEXT-FIG. 1. (a) Reconstruction of *Irvingella nuneatonensis* (Sharman), $\times 4$ approx.; (b) Diagram of the ventral aspect of the cephalon, showing rostrum; (c) Sketch of side-view of a young cephalon, $\times 8$ approx.

of the glabella and is slightly less long sagittally than the doublure of the free cheeks (text-fig. 1*b*). Hypostome not known.

Thorax of twelve segments, parallel-sided for the first seven, the eighth segment macropleural, the remainder narrowing to the pygidium. Axis convex, broad anteriorly, narrowing evenly behind. Anterior pleura about half as wide as the axis with a short spine springing from the anterior edge; in the second to seventh segments the pleurae are progressively wider and the spines longer. The spines on the remaining pleurae are broad and strong; the macropleurae on the eighth segment extend back to or beyond the pygidium, but the spines on the ninth to twelfth segments are progressively shorter.

Pygidium small, trapezoidal, about twice as wide as long. Axis occupies half the total width and most of the length of the pygidium, strongly convex, rounded and almost vertical behind, in larger specimens composed of three rings of which the last is only weakly marked off from the terminal part; in smaller specimens there are only two rings besides the terminal part. Pleural regions flat, furrowed obscurely or unfurrowed but

with a narrow, weakly marked border. In rear view the posterior margin is slightly arched (Pl. 52, fig. 12b).

The exoskeleton was up to 0.1 mm, thick and was fairly rigid (see under 'Material', above). From the form of the cracks which have affected some specimens, however, it may be inferred that it was not brittle but slightly flexible. Some of the best-preserved external moulds show that the exoskeleton was minutely granulose.

Measurements in mm.

				JR		JR	JR	JR
GSM specimen no.	50282	50283	50280	3137	50285	<u>3134</u>	3127	3125–6
Length of cephalic axis	1.5	2.4	2.8^{1}	6.4	6.9	8.1		
Width of occipital ring	0.9	1.7	2.5	5.0	5.7	6.7		
Width of glabella at S1	0.9	1.6	2.4	4.3	4.7	6.0		
Width of interocular cheek	0.6	1.1	1.2	2.2	2.4	3.2		
Length of frontal area	0.35^{2}	0.3		0.6	0.6	-		
Chord of palpebral lobe	1.0	1.7	2.2	3.9		5.1		
Length of thorax		4.5	5.5				12.5	
Length of pygidium		0.7	1.0				2·33	2.9
Width of pygidium		1.54	2.2					6.8

Foreshortened by frontal pressure.
Preglabellar field with anterior border.

³ Teratological pygidium.
⁴ Estimated figure.

The axial length of the lectotype (GSM 50280) is 9.3 mm. but before deformation it was probably about 9.6 mm. The largest specimen (SM A57283) has a thoracic axis 12.5 mm. wide, suggesting a total length for the whole trilobite of 40–50 mm.

Remarks. In general, Sharman's description is accurate, but the statement that the glabella bends over the anterior margin applies only to the lectotype, which has been affected by frontal pressure. Sharman also stated that there are 'eleven to thirteen bodyrings' and described the eighth as having a long spine. Two of Sharman's specimens (Pl. 52, figs. 6, 8) and one collected by the writer show complete holaspid thoraces with twelve segments and there is none with any other number. Of the fragmentary thoraces, none has more than seven segments anterior to the macropleural one or (with the exception of an abnormal specimen described below) other than four between it and the pygidium; the macropleural segment appears to be the eighth in every case and the thorax may be taken as normally having twelve segments. Sharman's comparison of the pygidium with that of *Olenus micrurus* Salter was apposite at that time; in 1908, however, Lake (p. 56, pl. 5, fig. 12) showed that the pygidium of the latter species has a small pair of marginal spines, whereas that of *I. nuneatonensis* has not.

The somewhat unusual shape of the thorax of *I. nuneatonensis* recalls that of *Leptoplastus abnormis* Westergård (1944) and to some extent that of *Centropleura* as described by Öpik (1961), who considered it supported his idea that *Centropleura* was a 'pelagic hunter'. *Irvingella* may have had a similar mode of life.

Abnorual development. Palmer (1965, pl. 6, fig. 11) illustrated an asymmetrical pygidium of *Irviugella major*; three examples of asymmetrical development have been noted in *I. nuneatoneusis*, in every case affecting the posterior part of the exoskeleton. In the specimen illustrated on Plate 52, fig. 6 (GSM 50283), the axial ring and right-hand pleura of the last (twelfth) thoracic segment are free but the left pleura is fused with the

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pygidium. This type of deformity has been illustrated in species of *Paradoxides* by Westergård (1936, pl. 8, fig. 4, and pl. 10). The pygidium of GSM JR3127, shown in Plate 52, fig. 11, and text-fig. 2a, has the second axial ring incompletely developed on one side (compare the occipital ring of *Rossaspis superciliosa* (Ross) illustrated in Harrington *et al.* 1959, fig. 82*c*, p. O110). It may be that the right-hand pleural part of this segment was not developed at all and that it is for this reason that the right pleural region of the pygidium is smaller than the left.



TEXT-FIG. 2. (a) Deformed pygidium of the specimen shown in Plate 52, fig. 11, GSM JR3127; (b) Deformed pleurae and pygidium, GSM JR3139. Both $\times 10$.

b

The anterior part of the fragmentary thorax and pygidium (GSM JR3139) shown in text-fig. 2b is, so far as can be seen, quite normal, including the macropleural segment and the one posterior to it; the latter two segments are accordingly taken to be the eighth and ninth, as usual. The tenth segment presents the normal appearance along its anterior margin but the posterior margin is oblique to the sagittal line, the pleura being abnormally swollen behind the spine and the ring apparently longer on the right than on the left. The eleventh and final free thoracic segment is also oblique to the sagittal line and has an unusually short pleural spine. The anterior margin of what appears to be the pygidium is oblique and it seems that either the first or second of the four axial rings seen on the fragment preserved is imperfectly developed in a manner somewhat similar to the second axial ring of the pygidium shown in text-fig. 2a.

Although the specimen appears to have had only eleven free thoracic segments it is too large for this to be ascribed to immaturity, and it seems likely that the abnormalities in form and in number of the posterior thoracic segments are connected in some way. The right pleura attached to the tenth axial ring has the appearance of being composed of two ankylosed pleurae, presumably the tenth and eleventh; if so, the eleventh axial ring may also be fused with the tenth, and the segment corresponding to the twelfth in the normal thorax appears as the eleventh here. Alternatively, if the swelling on the tenth pleura is a pathological growth, it may be surmised that this displaced or distorted the eleventh segment somewhat and caused the right-hand pleura of the twelfth segment

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to be suppressed altogether; in this case it would appear that the twelfth axial ring is fused with the pygidium.

Comparison with other species. Irvingella nuneatonensis is distinguished from the group of species separated by some authors as '*Parairvingella*' [*I. angustilimbata* Kobayashi, *I. convexa* (Kobayashi, not Ivshin), *I. megalops* (Kobayashi), *I. specioza* (Ivshin) and *I. tropica* Öpik] by the absence of a distinct anterior border and border-furrow in cranidia of mature specimens (more than 2.0 or 2.5 mm. long).

In *Irvingella major* Ulrich and Resser (see Palmer 1965, p. 48, pl. 6, figs. 9–15) the glabella is cylindrical and with a rounded front, not tapered and truncate anteriorly as in *I. nuneatonensis*, and it is more convex transversely; the eyes are longer with their anterior ends closer together, and (in large cranidia only) the interocular cheeks are narrower than half the glabellar width, not wider as in *I. nuneatonensis*.

The glabella of *I. floluri* Resser (see Palmer 1965, p. 47, pl. 6, figs. 16, 19, 20, 24) is much like that of *I. numeatonensis* except that in the former the S2 furrows are obscure and S3 absent; in large cranidia the interocular cheeks are narrower.

Irvingella transversa Palmer (1965, p. 48, pl. 6, figs. 7, 8) has wider interocular cheeks than *I. nuneatonensis*; the glabella is not tapered, the eyes are longer and their anterior ends are further apart.

The glabella of *I. suecica* Westergård (1947, p. 16, pl. 3, figs. 1–3, 5?, 6?, not fig. 4) is less convex longitudinally and has weaker S2 furrows than those of *I. nuneatonensis*, and S3 are absent; the anterior border persists to a later stage of growth and the anterior margin appears not to bend abruptly down as it does in *I. nuneatonensis* and other species of the genus.

I. nuneatonensis differs from *I. convexa* Ivshin (1962, p. 54; not *Komaspis (Parair-vingella) convexa* Kobayashi) by having a tapered glabella with S3 furrows present and wider cheeks. It differs also from *I. kassini* Ivshin (1962, p. 56) in having a tapered glabella with S2 and S3 present. The tapered glabella with S3 impressed likewise serves to separate it from the species *I. platycephala* described by Rusconi (1953).

Horizon and localities. The type-material was collected in 1886 by J. Rhodes from within the upper 250 ft. of the Outwoods Shales in Stockingford Railway Cutting, 1,200 yards N. 54° E. of St. Paul's Church, Stockingford, west of Nuneaton, Warwickshire (NGR SP3429.9207 or thereabouts); precise horizon uncertain. A few specimens of *Irvingella*, provisionally referred to *I. nuneatonensis* but with the diagnostic features not preserved, were collected by the writer in 1963 from a shallow excavation about 110 yards east by south of the Lodge in Parkhill Outwoods and 30 yards north of the Atherstone–Coleshill road (B4116), one mile south-west of Atherstone, Warwickshire (NGR SP2980.9654); the shale fragments were not definitely *in situ* but nevertheless probably came from the top 100 ft. of the Outwoods Shales.

The horizon is high in the Olenus Zone, not lower than the subzone of Olenus dentatus and quite probably higher.

The evidence both for the stratigraphical and zonal horizon given above is somewhat circumstantial and as the stratigraphical palaeontology of the Outwoods Shales has not been published the main points are stated below.

Illing (1913, p. 453) subdivided the 'Middle Stockingford' or 'Oldbury Shales' of Lapworth (1898, pp. 345–6) as follows:

	(Monks Park Shales				
Oldhumy Chalco	Moor Wood Flags and Shales				
Oldbury Shales	Outwoods Shales				
	Abbey Shales				

He published a map (Illing 1916, pl. 38) showing that the Outwoods Shales (which are somewhat over 1,000 ft. in thickness) crop out in Stockingford Railway Cutting. However, Mr. K. Taylor and I have noted fragments of the Moor Wood Flags at the extreme west end of this cutting. According to Lapworth (1898, pp. 346, 347) *Irvingella* [Olenus?] *nuneatonensis* was found at a somewhat higher horizon in Stockingford Cutting than 'Agnostns pisiformis var. sociale' (= Homagnostns obesus Belt sp.); since I have collected the latter species from a few horizons in the cutting up to about 250 ft. stratigraphically below the base of the Moor Wood Flags, *I. nuneatonensis* was probably collected from this 250-ft. interval. As mentioned above, the specimens of *Irvingella* collected by the writer appear to have come from the upper 100 ft. of the Outwoods Shales.

The zonal arrangement applied to the early Upper Cambrian of north-west Europe is as follows (Westergård 1947, pp. 20, 21):

Zones	Subzones
Parabolina spinulosa with Orusia lenticularis	(P. spinulosa P. brevispina
Olenus with Homagnostus obesus	O. scanicus with 'Polyphyma' angelini O. dentatus O. attenuatus O. wahlenbergi O. truncatus) with Glyptagnostus reticulatus O. gibbosus) reticulatus

Agnostus pisiformis

I have detected the Subzones of O. gibbosns, O. truncatus and O. wahlenbergi in the Outwoods Shales and have found that the last of these is overlain at a horizon some 400 ft. below the base of the Moor Wood Flags by Olenus cataractes Salter accompanied by Proceratopyge tullbergi Westergård; the latter species is recorded by Westergård from the upper part of the Subzone of O. dentatus and by Tullberg from the Subzone of Protopeltura aciculata (\equiv Parabolina brevispina; see Westergård 1947, p. 12). I. nuneatonensis occurs at a substantially higher horizon than that with P. tullbergi and O. cataractes, and is accordingly thought to be either above the Subzone of O. dentatus or possibly within its upper part.

The Moor Wood Flags have yielded no fossils, but in the Geological Survey Merevale No. 1 Borehole the lower beds of the overlying Monks Park Shales were found to contain *Parabolina* cf. *brevispina* Westergård, with *P. spinulosa* (Wahlenberg) at a somewhat higher horizon, both species being associated with abundant specimens of *Orusia lenticularis* (Wahlenberg). *I. nuneatonensis* thus appears to occur below the Subzone of *P. brevispina*. This conclusion is not in conflict with the situation in Sweden for although Westergård (1947, p. 17) originally considered that *I. suecica* possibly came from a